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**OC-ALC Aging Aircraft Disassembly
and Hidden Corrosion Detection Program**

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Corrosion has been a part of the aviation industry since metal was first used to build aircraft. It was recognized right away that corrosion was an undesirable condition for structural integrity, and so we coated, primed, painted and created corrosion resistant alloys to "prevent" corrosion, or at least lessen its impact. Until recently, limited corrosion prevention measures; combined with a "find it and fix it" maintenance philosophy has been adequate to combat the ravages of age on our aircraft. Unfortunately, that was when an aircraft life was relatively short. Today, we are flying our aircraft well beyond their original expected services lives, nature is starting to take its tool on the fleets, and we are caught without answers.

The OC-ALC Aging Aircraft Disassembly and Hidden Corrosion Detection Program was initiated by Mr. Donald Nieser of the KC-135 engineering office, because this is the very problem being experienced on the KC-135. This aircraft was built between 1955 and 1963 and still constitutes the backbone of the USAF tanker fleet. It was never meant to handle its mission for this long, and therefore was not constructed with corrosion prevention as a primary concern. The original construction was without any sealants in the lap joints, and in fact, most fuselage skins have spot welded doublers attached to them (that means metal to metal contact, with no protective coatings at all). The upper wing skins are 7178 aluminum with steel fasteners (a perfect area for dissimilar metal corrosion).

If we were to make an estimate of the fatigue life left in the aircraft based on current flight profiles, the tankers would be able to fly easily to the year 2000. This assessment, however, is based on pristine aluminum and, unfortunately, the KC-135 no longer has the luxury of being able to claim an uncorroded structure. The areas of the aircraft described above are showing signs of massive corrosion problems, and nobody has the analytical tools necessary to incorporate the effects of corrosion into the damage tolerance and service life predictions of the airplane. This program was developed to find those tools, at least in their preliminary forms.

To reach our goal, we needed to implement several key program elements. These elements are: the disassembly of a retired -135; the development of non-destructive inspection (NDI) equipment capable of finding hidden corrosion; the creation of a corrosion information system; structural integrity testing of corroded material; the creation of a corrosion predictive model; corrosion quantification; corrosion growth rate studies; and a service life prediction and extension study.

The disassembly of a recently retired -135 was one of the first program elements to be started. We took this aircraft and cut it into 3'X3' sections. These sections had the paint stripped off, all the fasteners removed, and the corrosion byproducts and dirt stripped off in a light etching process. All of the corrosion (and cracks) are being documented and we will create a map of airframe corrosion. This map will be supplemented by maintenance history and surveys and then compared with what is being found on the Program Depot Maintenance (PDM) line to determine where we need to be looking for corrosion in the future. What we have found so far, is that there are several areas on the aircraft that are very difficult to inspect, and we are finding these areas to have some rather severe corrosion. What is more alarming though, is that we are finding light and moderate corrosion everywhere on the aircraft. Areas that were thought to be corrosion free are definitely not, and we simply don't have the technology available to find this hidden corrosion.

Therefore, the second element of the program is to find solutions to the NDI dilemma. We invited any vendor that thought they might have a piece of off-the-shelf equipment capable of finding hidden corrosion in lap joints and around wing skin fasteners, to come to Oklahoma City and prove it. We cut coupons from actual aircraft and had the vendors try to find the corrosion and tell us how bad the corrosion was. Those vendors that did reasonably well were invited back to try their equipment on actual aircraft in the PDM line. From those vendors trying to find corrosion in the laps, we purchased three systems that showed promise. These systems are currently being put through a validation phase and procedural development phase for eventual imple-

mentation on the PDM line. As for those vendors trying to find wing skin corrosion, none were successful, and no systems were purchased. It is clear to us that both problem sets will require the development of new technologies to give us reasonable inspection results.

Another valuable tool not yet available to us is an accurate and comprehensive corrosion history of the KC-135. Maintenance history for this 35 year old aircraft is sketchy and incomplete, and most every action is still performed by shuffling paper. It is imperative that we be able to build a better history of the aircraft's corrosion problems. To that end, we are creating an Integrated Corrosion Data Base (ICDB). The ICDB will be capable of accessing all current information resources and reading the narrative in those records to help us build a better history. It will eventually be able to access I.O.s and drawings to help us better recognize problem areas on the aircraft and give faster engineering disposition on required areas. Eventually, the information collected by the ICDB will be invaluable in creating a predictive model for corrosion on the -135.

The predictive model, is currently being evaluated to determine if it is possible to do. An actual predictive model would require much more information on the nature of corrosion than is currently available. What we hope to do in the short term, is at least be able to predict where we will find corrosion on the airplane given its station and flight profiles.

Along with knowing where the corrosion will be, we will need to know what it's doing to the strength of the material. To this end, we are engaging in structural integrity testing of material from an actual -135. We are supplementing the testing with pieces of similar structure for old 707 aircraft. To start off with, we will be doing stress vs. cycle testing on actual lap joints from a -135. We are hoping that we will be able to find enough samples that are not corroded and some that have light natural corrosion to make the test viable. As far as determining the effect of severe corrosion, one of our contractors is developing a quick laboratory method to grow severe, uniform corrosion on the faying surfaces of lap joints. We are hoping to find a very rough order of magnitude delta for the service life of those lap joints. Eventually, we will be conducting crack growth rate testing in corroded material to be incorporated into the damage tolerance assessments for the aircraft.

To incorporate the effects of corrosion into any engineering assessment, we must be able to describe the corrosion in a quantitative manner. Currently, the only descriptions of corrosion available are qualitative in nature (light, moderate and severe) and are extremely subjective. We are trying to develop a method to quantify corrosion that relates it to its effect on crack growth rates and crack nucleating potential. This number or series of numbers may

incorporate pit density, pit geometry, area covered by the corrosion and any other number of parameters that are found to be of importance.

We will also need to be able to measure corrosion when we try to assess its growth rates. Our plan for growth rate testing is to take old aluminum out of a -135, and create new lap joints with it. This is to be sure we know that there is no pre-existing corrosion. These samples will be set in various corrosive environments around the world and samples will be brought back annually to measure the growth of the corrosion at those places. Some of these samples will also be outfitted with some newly developed corrosion sensors to assess the effectiveness of the sensors and possible help in understanding the corrosion growth process.

All of the above program elements will be used in a service life engineering study to be conducted at a later date. Not only do we want to find the effective usable life of the aircraft, but we want to know what steps will be necessary to make that usable life longer. We want to know what the economic life of the aircraft is, and whether or not we should just buy new airplanes. We want to revise the Aircraft Structural Integrity Program (ASIP) to include the effects of corrosion for the -135 and other aircraft. In the short term, we want to use the disassembly to tell us where to look for corrosion, use the NDI equipment to look there, the quantification to tell how bad it is, the structural integrity testing and growth rate studies to determine if its bad enough that we need to fix a problem now or if we can let it wait. In short, we need to learn how to manage corrosion damage in the same manner we do fatigue cracks.

Unfortunately, our program is extremely small in scope. If we are ever truly going to manage this program like we hope to do, every element of this program must be expanded by orders of magnitude. We hope to be able to provide some better answers for the KC-135, but time presses on, and with it corrosion, and we have a lot of catching up to do.